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PHYSIOLOGY.[1]

A Text-book of Physiology.[2]—Dr. Foster's work may well be regarded as epoch-making in the history of English text-books of physiology. Few authors have combined the capability and appreciative insight necessary to the treatment of this subject as a science. Physiology is a chain of reasoning connecting isolated phenomena, and the study of that subject calls into play to the fullest that mental discipline which gives the power of sifting the true from the false and the acquirement of which is, in a measure, the design of the student's labors. A great drawback to the general usefulness of Dr. Foster's book has been the fact that the discussions contained in it were on a scientific plane to which the average medical student could hardly transport himself. In the new edition, however, the author has sought by the omission of the discussions of many disputed points and by the introduction of new diagrams, to render his book especially useful to the medical student; there is given us, accordingly, a clear presentation of practical information in which, at the same time, the scientific aspects of physiology are held in full view.

Comparisons of Strength between large and small Animals.—M. Delbeuf, in a paper read before the Academie Royale de Belgique and published in the *Revue Scientifique*, reviews the attempts of various naturalists to make comparisons between the strength of large animals and that of small ones, especially insects, and shows that ignorance or forgetfulness of physical laws vitiate all their conclusions:

After a plea for the idea, without which the fact is barren, M. Delbeuf repeats certain statements with which readers of modern zoölogical science are tolerably familiar, such as the following: A flea can jump two hundred times its length; therefore a horse, were its strength proportioned to its weight, could leap the Rocky mountains, and a whale could spring two hundred leagues in height. An Amazon ant walks about eight feet per minute, but if the progress of a human Amazon were proportioned to her larger size, she would stride over eight leagues in an hour, and if proportioned to her greater weight, she would make the circuit of the globe in about twelve minutes. This seems greatly to the advantage of the insect. What weak creatures vertebrates must be, is the impression conveyed.

But the work increases as the weight. In springing, walking, swimming or any other activity, the force employed has first to overcome the weight of the body. A man can easily bound a height of two feet, and he weighs as much as a hundred thousand grasshoppers, while a hundred thousand grasshoppers could leap no higher than one—say a foot. This shows that the vertebrate has the advantage. A man represents the volume of fifteen millions of ants, yet can easily move more than three hundred feet in a minute, a comparison which gives him forty times more power, bulk for bulk, than the ant possesses. Yet were all the conditions compared, something like equality would probably be the result. Much of the force of a moving man is lost from the inequalities of the way. His body, supported on two points only when at rest, oscillates like a pendulum from one to the other as he moves. The ant crawls close to the ground, and has only a small part of the body unsupported at once. This economizes force at each step, but, on the other hand, multiplies the number of steps so greatly, since the smallest irregularity of the surface is a hill to a crawling creature, that the total loss of force is perhaps greater, since it has to slightly raise its body a thousand times or so to clear a space spanned by a man's one step.

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[1] This department is edited by Professor Henry Sewall, of Ann Arbor, Michigan.

[2] A Text-Book of Physiology. By Dr. M. Foster, M.A., M.D., F.R.S. 4th (Eng.) ed.

By what peculiarity of our minds do we seem to expect the speed of an animal to be in proportion to its size? We do not expect a caravan to move faster than a single horseman, nor an eight hundred pound shot to move twelve thousand eight hundred times further than an ounce ball. Devout writers speak of a wise provision of Nature. "If," say they, "the speed of a mouse were as much less than that of a horse as its body is smaller, it would take two steps per second and be caught at once." Would not Nature have done better for the mouse had she suppressed the cat? Is it not a fact that small animals often owe their escape to their want of swiftness, which enables them to change their direction readily. A man could easily overtake a mouse in a straight run, but the ready change of direction baffles him.

M. Plateau has experimented on the strength of insects, and his facts are unassailable. He has harnessed carabi, necrophori, June-beetles (Melolontha) and other insects in such a way that, with a delicate balance, he can measure their powers of draught. He announces the result that the smallest insects are the strongest proportioned to their size, but that all are enormously strong when compared, bulk for bulk, with vertebrates. A horse can scarcely lift two-thirds of its own weight, while one small species of June-beetle can lift sixty-six times its weight. Forty thousand such June-beetles could lift as much as a draught-horse. Were our strength in proportion to this we could play with weights equal to ten times that of a horse, while an elephant could move mountains.

This seems, again, great kindness in Nature, to the smaller animal. But all these calculations leave out the elementary mechanical law: "What is gained in power is lost in time." The elevation of a ton to a given height represents an expenditure of an equal amount of force, whether the labor is performed by flea, man or horse. Time supplies lack of strength. We can move as much as a horse by taking more time, and can choose two methods—either to divide the load or use a lever or a pulley. If a horse moves half its its own weight three feet in a second, while a June-beetle needs a hundred seconds to convey fifty times its weight an equal distance, the two animals perform equal work proportioned to their weights. True, the cockchafer can hold fourteen times its weight in equilibrium (one small June-beetle sixty-six times), while a horse cannot balance nearly his own weight. But this does not measure the amount of oscillatory motion induced by the respective pulls. For this both should operate against a spring.

A small beetle can escape from under a piece of cardboard a hundred times its weight. Pushing its head under the edge and using it as a lever, it straightens itself on its legs and moves the board just a little, but enough to escape. Of course, we know a horse would be powerless to escape from a load a hundred times its own weight. His head cannot be made into a lever. Give him a lever that will make the time he takes equal to that taken by the insect, and he will throw off the load at a touch. The fact is that in small creatures the lack of muscular energy is replaced by *time*.

Of two muscles equal in bulk and in energy the shortest moves most weight. If a muscular fiber ten inches in length can move a given weight five inches, ten fibers one inch long will move ten times that weight a distance of half an inch. Thus smaller muscles have an absolutely slower motion, but move a greater proportional weight than larger. The experimenter before mentioned was surprised to find that two grasshoppers, one of which was three times the bulk of the other, leaped an equal height. This was what might be expected of two animals similarly constructed. The spring was proportioned to the bulk. In experiments on the insects with powerful wings, such as bees, flies, dragon-flies, etc., it was found that the weight they could bear without being forced to descend was in most cases equal to their own. In some cases it was more, but the inequality of rate of flight, had it been taken into the reckoning, would have accounted for this.

Take two creatures of different bulk but built upon exactly the same plan and proportions, say a Brobdignagian and a Lilliputian, and let both show their powers in the arena. Suppose the first to weigh a million times more than the second. If the giant could raise to his shoulder, some thirty-five feet from the ground, a weight twenty thousand pounds, the dwarf can raise to his shoulder, not, as might be thought, a fiftieth of a pound, but two full pounds. The distance raised would be a hundred times less. In a race the Lilliputian, with a hundred skips a second, will travel an equal distance with the giant, who would take but a skip in a second. The leg of the latter weighs a million times the most, but has only ten thousand times as many muscle fibers, each a hundred times longer than those of the dwarf, who thus takes one hundred skips while the giant takes one. The same physical laws apply to all muscles, so that, when all the factors are considered, muscles of the same quality have equal power.—*W. N. Lockington.*

THE DIRECT INFLUENCE OF GRADUAL VARIATIONS OF TEMPERATURE UPON THE RATE OF BEAT OF THE DOG'S HEART.—In the Proceedings of the Royal Society, Professor Martin, of Johns Hopkins University, describes his researches upon the effect of changing temperatures upon the rate of beat of the dog's heart. The heart was perfectly severed from all physiological connection with the rest of body, with the exception of the lungs, and was nourished by an artificial stream of whipped blood. "As the result of many experiments it was found (1) that the isolated dog's heart beats quicker when supplied with warm blood, and slower when cold blood is supplied to it; (2) that the rate of beat depends much more upon the temperature of the blood in the coronary arteries than on its temperature in the right auricle or ventricle; (3) that when defibrinated calf's blood is used to feed the heart, that organ cannot be kept alive as long as when defibrinated dog's blood is employed; (4) that no matter how long an experiment lasts, the defibrinated blood, circulated again and again through the heart and lungs, shows no tendency to clot; hence fibrinozen is not produced in those organs.

The question answered by the first of the above results was the one for whose solution the research was undertaken. The experiments show that, in spite of its highly developed extrinsic nervous apparatuses, the heart of the mammal does, so far as its rhythm is concerned, in its own nerve-muscular tissues, respond to temperature variations within wide limits (42°–27° C.), just as the frog's heart or that of the embryo chick does. To account for the quick pulse of fever we, therefore, need not look beyond the mammalian heart itself; we require no theoretical assumption of any paralysis of inhibitory, or any excitation of accelerator cardio-extrinsic nerve-centers.

SKIN VISION.—In a recent communication to the Vienna Academy, Professor Graber, of Czernowitz, describes a long series of experiments with regard to the "skin-vision" of animals, affording exact proof that certain animals, without the aid of visual organs proper, can make not only quantitative but qualitative distinctions of light. These experiments relate chiefly to the earthworm as representing the eyeless (or " dermatoptic) lower animals, and to the *Triton cristatus*, as representative of the higher (" ophthalmoptic") eyed animals. In a table Professor Graber presents columns of numerical "cœfficients of reaction," indicating how many times more strongly frequented a space illuminated with bright red, green or white without ultra-violet, is, than one illuminated dark blue, green or white, with ultra-violet respectively, the conditions being the same as regards light, intensity, radiant heat, etc. In one set of experiments the animals were in the normal state; in another, the anterior end of the worm, and the eyes of the Triton were removed.—*Nature.*

PHOSPHORESCENCE AND RESPIRATION IN ANNELID WORMS.—Mr. W. A. Haswell has investigated the structure and functions of the elytra or scales, the possession of which is one of the most characteristic peculiarities of the Aphroditacea.

With regard to the functions of the elytra, the author distinguishes (1) protection, (2) production of phosphorescent light, (3) sensation, (4) respiration and (5) incubation.

The protective function is in some cases the predominating one. Thus in Iphione the scales are of extreme density, and cover the entire dorsal surface with a complete armor. In others the scales, though tough, are more readily detached, and in many instances do not completely cover the dorsal surface, or are so delicate and so readily parted with when the animal is irritated, that their direct protective action must be very slight.

When certain species of Polynoë are irritated in the dark, a flash of phosphorescent light runs along the scales, each being illuminated with a vividness which makes it shine out like a shield of light, a dark spot near the center representing the surface of attachment where the light-producing tissue would appear to be absent. The irritation communicates itself from segment to segment, and if the stimulus be sufficiently powerful, flashes of phosphorescence may run along the whole series of elytra, one or more of which then become detached, the animal meanwhile moving away rapidly and leaving behind it the scale or scales still glowing with phosphorescent light. The species in which the phenomenon of phosphorescence occurs are species characterized by the rapidity of their movements, and also by the readiness with which the scales are parted with; and it seems not at all unlikely that the phosphorescence may have a protective action, the illuminated scales which are thrown off distracting the attention of the assailant in the dark recesses which the Polynoidæ usually frequent.

That the elytra act, like dorsal cirri, as organs of some special sense, seems probable from their abundant innervation, as well as from the presence, in many instances, of fimbriæ and other appendages, some of which act as end organs for the nerve branches.

In Aphrodita and Hermione the scales have been observed by Williams and Quatrefages to perform an important mechanical function in connection with respiration. In these genera the dorsal surface is covered with a coating of felted hairs, which stretch across from one side to the other, and enclose a canal open in front and behind, and having for its floor the dorsal wall of the body with the elytra and the "branchial" tubercles. These authors regard the oxygenation of the perivisceral fluid as taking place through the thin integument covering the scale tubercles and the tubercles at the bases of the dorsal cirri, and having observed the scales to be subject to rhythmical movements by means of which a current of water is driven continually over the dorsal surface, thus renewing the water in contact with the "branchiæ." In species in which the felt-like dorsal covering does not exist, this function would appear to be in abeyance; and in Polynoë and allied genera, so far as Mr. Haswell has observed, the elytra remain perfectly motionless, while the animal as a whole is at rest.

The sexual products reach the exterior through apertures in the bases of the parapodia; and the ova are carried by ciliary action to the under surface of the scales, where they remain, adhering by means of a viscid matter till the embryos are well advanced. Impregnation probably takes place while the eggs are in this situation.—*Journal of Royal Microscopical Society.*

PSYCHOLOGY.

MATERNAL ANXIETY IN A HORNED TOAD.—I cannot designate the species of Phrynosoma, to which reference is here made, but my informant, to whom I showed several engravings, thinks it is *P. cornutum.* The following, which I am led to communicate with complete confidence in its truthfulness, I have taken from a friend, an educated lawyer: A full statement from him has been made to me several times, at intervals of some months. I made notes, and find my communicant agreeing closely in his facts every time. Hence I give the following as the pith of his statements:

It was near the South Platte cañon, where the foot hills reach the plains, on an afternoon in May, 1880. I was walking along a disused lumber road, when my attention was drawn to the strange movements of a horned toad. Instead of running away from me, I soon saw that it was making painful efforts to screen a young one from my observation. I was deeply impressed with the fact that it was a mother solicitous to save her little one from danger. The young one acted wildly, and aimlessly; and in manifest distress the mother would interpose herself between it and me, occasionally with a sidling motion against the young one, she would give its movements a direction of her own. In this way she got the little thing into a depression in the soil, where it squatted. I made no motion, but simply watched. But now, suddenly, the mother changed her conduct, which in fact became actually tactical, for she now tried to decoy me to herself, by making a short, rapid run at right angles to the line which I was taking. Then she stopped, and looked back. She would retrace a little distance of her flight, then turn again, and make another spurt of a run. I am positive that she was doing all this to with-